camera lens/CCD system **20** (which may include a filter **22**, or a plurality of filters **22**), at least one illumination source **30** and a user interface **45** that includes, for example, a display (LCD) **40** and a keypad or keyboard **50**. A touch screen, a color display, or any other suitable interface may be used as well, or in place of other interface components. The illumination source **30** can be a variable intensity source controlled by an operator, and it can also include a flash source, such as a xenon flash. The illumination source **30** may contain an adapter that provides for interchangeability of illumination sources **30**. However, in some embodiments, the illumination source **30** may not be necessary depending on the ambient illumination conditions.

[**0077**] The lens/CCD system **20** and illumination source **30** can be located on a surface opposite that of the display and keyboard **50**, enabling the operator to view the image being captured on the display **40**, and to manipulate the keys of the keyboard **50** such as to adjust the color measurement process, initiate the operation of the color measurement software (CMS) **15**A stored in the memory **15** or storage **18**, and perform other functions, such as initiating a transfer of data to a remote location via a wireless network link **60** having, for an RF embodiment, an antenna **60**A. The lens/CCD system **20** includes a digital camera of adequate resolution (e.g., 1.45 mega pixels or greater), with appropriate support circuitry providing auto-focus and other typically found features. The lens/CCD system **20** may include any photosensitive imaging sensor that is considered appropriate, such as, in a non-limiting example, a gray-scale CCD or a CMOS array. In preferred embodiments, the device **5** does not include gamma correction, automatic gain adjustment, or otherwise include other color or light compensating features.

[**0078**] In an exemplary embodiment of a lens/CCD system **20** for practice of the teachings herein, the following components may be included. A chip CCD sensor, having features such as model ICX205AK, which is available from Sony Corporation, may be included. This chip includes a ½-inch optical interline CCD solid-state image sensor with a square pixel array and 1.45M effective pixels. The chip is capable of progressive scan for independent output of all pixel signals within approximately 1/7.5 second. A frame rate readout mode supports approximately 30 frames per second. The chip includes an electronic shutter with variable charge-storage time that provides for generation of a full-frame still image without a mechanical shutter. High resolution and high color precision are achieved through the use of R, G, B primary color mosaic filters **22**. Further, high sensitivity and low dark current are achieved through the adoption of HAD (Hole-Accumulation Diode) sensors.

[**0079**] **FIG. 3** depicts color response of one chip that is suited for practice of this invention.

[**0080**] Preferably, the CCD/lens system **20** includes, without limitation, a 2 element telecentric, achromatic system; a multi-position filter wheel; provides for incremental steps from f/3 to f/24 (with a default aperture setting of f/5.82 for use with the teachings herein); a shutter speed ranging from 1/2000 second to 2 seconds; a focus range 1.25" to infinity (with a default focus of about 8 cm for use with the teachings herein); a Wratten™ 2-E filter (of Eastman Kodak Corporation, Rochester, N.Y.) to pass only UV light; a full-motion video capability to aid in positioning and attaining best focus; and an IR filter to sharpen the red long edge.

[**0081**] **FIG. 4** depicts one example of a transmission spectrum for a Wratten™ 2-E filter.

[**0082**] Preferably, the illumination system **30** includes a replaceable high power xenon flash lamp module which plugs into the device **5**. In a preferred embodiment, the life expectancy of the flash module is approximately 50,000 flash cycles. Various filters **22** can be interchanged in the lens/CCD system **20** to account for different types of illumination **30**. Examples of types of illumination include, without limitation: standard white, which may be useful for capturing images and scanning standard monochromatic barcodes, deep blue, which may be useful for certain authentication systems, and ultraviolet, which is preferred for decoding invisible barcodes, fluorescing marking systems, and for use with this invention for obtaining images of fluorescent security features such as particles.

[**0083**] **FIG. 5** depicts one embodiment of a system response spectrum for an illumination with UV and IR filters in place. **FIG. 6** depicts typical UV flash spectra for two separate illumination sources **30**.

[**0084**] The device **5** may be battery powered, or powered by an external power supply. Preferably, the device **5** is sized so that it can be readily manipulated with one hand by the operator, in much the same manner that a digital camera or a wireless communications device can be manipulated by a user. An optional microphone **25** can be provided for use with the embodiment that includes a wireless transceiver.

[**0085**] In accordance with a preferred embodiment, the memory **15**, or more preferably, the non-volatile storage **18**, includes one or more data sets where each data set represents a color space model, or CCA **18**A. Each CCA **18**A, also referred to herein as a "color classification algorithm," or "algorithm," includes information for derivation of color coordinates. For example, in one embodiment, the CCA **18**A represents the HUNTER LAB™ Color Space, which is a product of Hunter Associates Laboratory of Reston, Va.

[**0086**] The HUNTER LAB™ Color Space is a three dimensional rectangular color space based upon the opponent-colors theory. The three coordinates (L, a, b) represent aspects of any single color within a spectrum of colors. "L" represents a lightness axis, where 0 is black and 100 is white; "a" represents a red-green axis, where positive values are red, and negative values are green; and, "b" represents a blue-yellow axis, where positive values are yellow, and negative values are blue. Input observation data is fed into certain expressions to derive each color coordinate. In this exemplary embodiment, these expressions are: $L=100(Y/Y_n)^{1/2}$; $a=K_a(X/X_n-Y/Y_n)/(Y/Y_n)^{1/2}$; and, $b=K_b(Y/Y_n-Z/Z_n)/(Y/Y_n)^{1/2}$; where K_a and K_b are system coefficients. The input observation data is described by the tri-stimulus variables X, Y and Z. In this embodiment of a CCA **18**A, the respective expressions for L, a, and b with coefficients K_a and K_b are included in the CCA **18**A, as well as instructions for the derivation of the X, Y and Z values from image data. In other embodiments, information required to enable use of other color schemes, such as but not limited to the CIE 2° or CIE 10° scheme is assembled into a CCA **18**A. An illustration of the HUNTER LAB™ Color Space is shown in **FIG. 7**.

[**0087**] In **FIG. 7**, two color samples are shown. The colors are at the extrema of the L axis, and appear in black (L=0)